

factory configuration is attained, the coil is detached from the delivery wire by electrolysis. The objective is to pack the aneurysm with a sufficient number of coils to induce endosaccular thrombosis and occlusion, thus preventing arterial inflow. This technique obviates the need for a surgical craniotomy. Approximately 27,000 patients have undergone this treatment.

The most satisfying technical results are seen in smaller aneurysms (<12-mm diameter) with narrow necks. Wide-necked aneurysms remain technically challenging because of the proclivity of coil loops to cross the broad neck and herniate into the parent arterial lumen. Fusiform aneurysms also remain a challenge because occlusion of the aneurysm lumen usually results in simultaneous blockage of the parent artery.

In addition to factors related to aneurysm morphology, the feasibility of endovascular aneurysm treatment also relates to the aneurysm site. Middle cerebral artery aneurysms are usually more difficult to treat because of more complex anatomical arrangements encountered in this location. For treatment of posterior circulation aneurysms, however, endovascular techniques may offer advantages over surgical clipping because of difficult surgical access and the risk of injury to small arterial perforator vessels and neural structures. Other potential advantages of the endovascular route over surgery are that brain retraction is avoided (especially relevant in acute aneurysms where the brain may be swollen and edematous), and the ability to stage procedures in medically compromised patients with large or complex acute aneurysms.

A longer-term problem associated with the use of GDC is the phenomenon of coil compaction. Over time the endosaccular coil conglomerate may compact, resulting in partial recanalization of the aneurysm, usually at the neck. For this reason, follow-up angiography is necessary. The likelihood of coil compaction may correlate to the density and completeness of the original coil pack, the size of the aneurysm and aneurysm neck, the presence of aneurysm thrombus, and the position of the aneurysm. End-artery locations such as terminal carotid or basilar tip aneurysms may be prone to coil compaction because the direction of the arterial inflow vector is perpendicular to the aneurysm neck, producing a so-called water-hammer effect against the coils.

The largest published series examining the efficacy of the GDC system in treatment of acute subarachnoid hemorrhage is a North American multi-center prospective trial in which 403 patients were enrolled. All of these patients were excluded from aneurysm surgery because of technical difficulty, poor medical condition, or other reasons and therefore represent a high-risk group. The proportion of posterior circulation aneurysms within this cohort was 57%. The overall reported rates of morbidity and mortality were 9% and 6% respectively. These figures compare favorably with the natural history of untreated ruptured aneurysms. The data suggest that GDC embolization in subarachnoid hemorrhage may be less effective in giant aneurysms (>2.5-cm. diameter) and may not improve clinical outcomes in those patients with

pre-existent poor clinical status. A European multicenter prospective randomized controlled trial comparing surgery to endovascular treatment of ruptured aneurysms is currently in progress. Rebleeding rates following endovascular coiling remain to be defined. The preliminary data are encouraging, however, indicating an overall rebleeding rate of 0.5% or less per annum. A recent prospective study of clinical outcomes (average of 3.5 years follow-up) found 86% of 61 patients treated with GDC for acute subarachnoid hemorrhage had an excellent or good outcome.

Valid comparisons of morbidity and mortality with surgical clipping in acute subarachnoid hemorrhage, particularly with respect to anterior cerebral circulation aneurysms (and especially anterior communicating artery aneurysms which overall are the most common) are difficult to make using the current data. The results of prospective randomized controlled trials are awaited. Endovascular technology, however, continues to evolve rapidly, as does clinical expertise with these techniques, forecasting further improvement in healing aneurysms using the endovascular route.

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## Extracranial Carotid Stenosis: Ultrasound, MRI, Angiography

IN EXPERIENCED HANDS, with proper instrumentation, vascular ultrasound is the screening study of choice for extracranial carotid artery disease because it is accurate, non-invasive, and the least costly of the three main options. This technique uses bilateral morphologic images to assess the extent of plaque and tortuosity, and to determine whether there is a high carotid bifurcation.

Another essential component is an evaluation of flow dynamics using color Doppler, and spectral analysis in the internal carotid artery, the external carotid artery, the vertebral artery, and the proximal, mid, and distal portions of the common carotid artery.

To assure quality of operator and instrumentation, the sonogram should be done in an accredited laboratory under the supervision of an experienced registered vascular technologist. Laboratory accreditation is obtained through either the Intersociety Commission for the Accreditation of Vascular Laboratories or the American College of Radiology Vascular Ultrasound Accreditation Program.

If the carotid stenosis is greater than 70% and there is no suggestion of other complicating factors, some surgeons will proceed directly to carotid endarterectomy, depending upon whether the sonogram is technically adequate. Others prefer to corroborate the sonogram before surgery with magnetic resonance angiography (MRA), particularly if questions exist. A confirmatory study is important if flow is damped, suggesting bilateral carotid ostial disease (or cardiac disease) out of the field of view of ultrasound that can be visualized by MRA. Other indications for MRA confirmation are detection by sonography of elevated carotid velocities, which may result from shunted flow from a significant lesion of the opposite carotid artery; suspected internal carotid occlusion; or highly resistant flow in a normal-appearing carotid artery, suggesting dissection out of the sonographic field of view.

MRA is also indicated in evaluating for random lesions and to differentiate between vessel occlusion versus "angiographic string sign" suspected on ultrasound.

Carotid catheter angiography has historically been the standard to which the other studies are compared. The examination has inherent risks, albeit low, but with potential for morbidity and even mortality. Recent studies suggest that when compared with the actual carotid specimen removed intact at the time of endarterectomy, extra-cranial carotid artery disease is significantly underdiagnosed by catheter angiography. Angiography, however, remains an integral part of the workup in that small group of patients in which there is a discrepancy between the ultrasound and magnetic resonance angiographic studies.

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## Ultrasound versus CT in Evaluating Blunt Abdominal Trauma

INJURIES FROM BLUNT trauma are primarily the result of motor vehicle accidents, and continue to increase along with motor vehicle use in the United States and worldwide. Rapid diagnosis and early surgical intervention decrease morbidity and mortality from these injuries. To detect intraabdominal injury from blunt trauma, emergency physicians and trauma surgeons have several options: physical examination, laboratory tests, observation, diagnostic peritoneal lavage, ultrasound, and computerized tomography (CT).

Physical examination and laboratory tests are not accurate in detecting intraabdominal injury. The presence of abdominal tenderness to palpation is neither

sensitive nor specific for intraabdominal injury, and is unreliable in obtunded or unconscious patients. Patients with multiple distracting injuries will also have unreliable abdomen exams. Laboratory tests indicating fall in hematocrit greater than 5% or abnormal liver function are questionable. Admission to the hospital and observation may be useful in the diagnosis of subtle or occult intraabdominal injury—including bowel and mesentery injuries—which are notoriously difficult to detect with imaging studies. Admission and observation may also be appropriate for selected spleen and liver injuries for which non-operative management has been chosen. In the era of managed care and shrinking medical resources, however, the practice of admission for observation is declining.

Diagnostic peritoneal lavage remains the most sensitive method for detecting intraabdominal injury, and is indicated for obtunded or unconscious patients. The majority of blunt trauma patients treated by emergency physicians are stable and awake, however, and diagnostic peritoneal lavage is inappropriate for this subgroup. It is also an invasive procedure requiring a substantial amount of time and effort, making it difficult for the busy emergency physician to perform alone. It is more appropriate for a trauma center with a dedicated trauma team. A positive diagnostic peritoneal lavage provides no information about the site of bleeding and does not identify isolated retroperitoneal injuries. Because of the extreme sensitivity of this technique, a greater number of non-therapeutic laparotomies have been reported from the use of diagnostic peritoneal lavage as an initial screen for intraabdominal injury.

Ultrasound has many qualities which make it an attractive initial screening test for intraabdominal injury. It is portable, rapid, noninvasive, and relatively inexpensive, and it involves no parenteral or oral radiocontrast exposure. It can be performed during the trauma resuscitation. Serial ultrasound examinations are easily obtained.

Reported sensitivities for detection of intraabdominal injury range from 63% to 100%. There are variations in study design and method of scanning, however. The amount of intraperitoneal fluid required for ultrasound detection remains unclear, but is widely regarded as approximately 500 mL. Although some studies utilize a single scan of the hepatorenal interface (Morison's pouch), which is considered positive if a stripe of fluid is seen, the single view has largely been abandoned, and a more comprehensive sonographic examination has evolved.

Focused abdominal sonography in trauma (FAST) is now the most commonly used method worldwide in the detection of intraabdominal injury. The FAST scan can be completed in less than 5 minutes and involves up to 6 views: (1) subxiphoid to detect pericardial effusion; (2) right upper quadrant view to assess Morison's pouch, diaphragm, liver, and kidney; (3) left upper quadrant to assess the splenorenal interface, spleen, diaphragm, and kidney; (4 and 5) right and left flank to assess kidneys; and (6) longitudinal pelvis to look for free fluid adjacent to the bladder. The development of the FAST technique